Smartness of Learning Ecosystems and its bottom-up emergence in six European Campuses

Giovannella, Carlo; Andone, Diana; Dascalu, Mihai; Popescu, Elvira; Rehm, Matthias; Roccasalva, Giuseppe

Publication date:
2015

Document Version
Early version, also known as pre-print

Smartness of Learning Ecosystems and its bottom-up emergence in six European Campuses.

CONFERENCE PAPER · SEPTEMBER 2015

6 AUTHORS, INCLUDING:

Carlo Giovannella
University of Rome Tor Vergata
147 PUBLICATIONS **411** CITATIONS
SEE PROFILE

Diana Andone
Polytechnic University of Timisoara
63 PUBLICATIONS **48** CITATIONS
SEE PROFILE

Matthias Rehm
Aalborg University
98 PUBLICATIONS **716** CITATIONS
SEE PROFILE

Giuseppe Roccasalva
Politecnico di Torino
1 PUBLICATION **0** CITATIONS
SEE PROFILE

Smartness of Learning Ecosystems and its bottom-up emergence in six European Campuses.

Carlo Giovannella[1, 2], Diana Andone[3], Mihai Dascalu[4], Elvira Popescu[5]
Matthias Rehm[6], Giuseppe Roccasalva[7]

[1] ISIM_Garagre, Dept. of Educational Science and Technologies
University of Rome Tor Vergata, Rome, Italy
info@mifav.uniroma2.it
[2] Creative Industries, Consorzio Roma Ricerche, Rome, Italy
giovannella@romaricerche.it
[3] Politehnica University of Timisoara, Romania
diana.andone@cm.upt.ro
[4] Faculty of Automatic Control and Computers, University Politehnica of Bucharest, Romania
mihai.dascalu@cs.pub.ro
[5] Computers and Information Technology Department, University of Craiova, Romania
popescu_elvira@software.ucv.ro
[6] Department of Architecture, Design and Media Technology - Aalborg University, Denmark
matthias@create.aau.dk
[7] Department of Architecture and Design, Polytechnic of Turin, Italy
giuseppe.roccasalva@polito.it

Abstract. Each year a considerable amount of money is spent on the production of several national and international University rankings that may deeply influence the students' enrollment. However, all such rankings are based almost exclusively on numerical indicators weakly related to the quality of the learning process and do not consider the perceptions of the "end users": the learners. Recently, as part of the activity promoted by the Observatory on the Smart City Learning, we have produced an alternative approach to benchmark the learning ecosystems based on the satisfaction of the needs described by the Maslow's Pyramid and on the achievement of the state of "flow" by the actors involved in the learning processes. Here we report on the first validation of such a benchmarking approach that has been tested in six European Campuses involving more than 800 students. The critical analysis of the outcomes allowed us, among other results, to identify the set of the most relevant indicators out of those that were initially proposed and the identification of a "smartness" axis on the plan of the first two principal components derived from a Principal Component Analysis (PCA) applied to the collected data.

Keywords: Learning Ecosystems, University ranking, Benchmarking, Smartness, Maslow's Pyramid, Flow, Principal Component Analysis

1 Introduction

Since their emergence, universities have established as places for a privileged transmission of knowledge and know-how. For a long time the students' choice to attend one university rather than another was linked to the personality of its teaching staff that, on the other hand, were allowed to operate in a favorable context that made "easy" to develop what are usually known as "schools of disciples". In order to survive universities had to attract the relatively few available students and talents, and be clearly recognizable not only at territorial level. With the massification of the higher education, universities have assumed a different social role and became drivers of local economies, regardless of the quality of the educational processes and of theat of the overall faculty. The abundance of suppliers has shifted the parents' focus, with few exceptions, from *quality* to *proximity*, while the universities with the time have given an increasing importance to the establishment of relation systems, at the expense of meritocracy. Moreover universities adapted themselves to act as an enterprise capable to deliver *services* adaptable to the needs of the *market*, rather than to the needs of the *society*.

In this context, the potential *student* has often become a potential *customer* to attract and insert into the process that transforms the *raw material* into the *product* needed by the market. The multiplication of suppliers, together with the growing adoption of marketing techniques have made the scenery increasingly opaque and the students' selection process difficult and doubtful. Therefore, in recent years many subjects started to produce university ranking either at global and national level in order to support students in their choices.

Obviously, no ranking can be considered neutral because all are built up on model assumptions from which indicators and indices are derived and suitably combined to produce the ranking. Potential users of the ranking - future students and their parents - are almost never capable of identifying the model of reference and, thus, are not able to assign the proper value to the ranking to to evaluate the actual reliability of the underlying method. For example, the two rankings of Italian universities [1,2] were recently critically analyzed and it has been shown [3] that they:

a) are based on numerical *process* and *product* indicators (intended to detect the quality of the research, of the delivered process, the level of internationalization and, in part, the capability to connect the process with the productive environment)

b) use indicators strongly correlated among themselves that would require an appropriate statistical treatments to determine the best space of representation

c) are correlated with the territorial ranking (i.e. smart cities rankings).

The analysis of the correlations among indicators, moreover, has shown that macro-analysis of comparable quality can be obtained also by considering only a subset of the initial indicators. This, of course, in turn, would enable the optimization of work

needed to produce the rankings by reducing time and efforts necessary for data retrieving and, as well, the associated costs.
It is important to emphasize that, in the creation of such rankings, students' opinions are scarcely taken into account. In one of the two previously rankings students were considered only as a normalization factor and for their propensity for international mobility [1]. In the other one [2], apart from the role of normalizing factor, students being considered as a product destined to the labor market, are involved in the benchmarking because of their performances, These latter, un fact, are related to the measure of effectiveness and efficiency of the overall process having as goal also the satisfaction of the territory's expectation. In this framework the only exception is represented by the possibility that the students have to express an opinion on the integrated quality of the offer (*product*) and of the learning courses (*process*).

Not dissimilar from the one described above is the present international landscape. Among the most popular university classification systems there are Topuniversities [4] and U-Multirank [5]. The first one ranks universities by assigning 60% of the score to the *research "quality"* (reputation and number of scientific papers citations), 10% to the *level of internationalization* (students and teachers), 10% to the *outcomes of the process* (reputation of former students in their working environment) and 20% to the *staff/student ratio*. We can certainly state that this ranking does not put the students at the center of the evaluation.
The second one, U-Multirank, is supported by the Erasmus+ initiative and monitors the quality of the universities on the basis of
a) *effectiveness and efficiency of the process* (percentage of graduates and percentage of non-employees)
b) *research "quality"* (total number of publications produced and citations) and the level of interdisciplinarity;
c) *knowledge transfer* (industrial relations, patents, spin-offs) with emphasis on the regional level of engagement: internships, local funding, job placement, joint research at local level;
d) *international propensity* (courses in English or activated in collaboration with foreign universities, percentage or foreign students and teachers, students' propensity to mobility).
Also U-Multirank's indicators and indices, as one may expect, are affected by correlations that have not been investigated by the proponents. However, U-Multirank, has the merit not to propose itself as a ranking tool. Nevertheless, similarly to the other ranking methods it does not consider students' expectations and/ot perceptions.
Although some of the dimensions considered by the evaluation approaches described above may be, to some extent, related to the attractiveness of the learning environment, they are inexorably linked to a top-down and "productive" vision. This perspective considers universities as *factories* that have to place efficiently their

products (innovative knowledge and human resources) into the *productive context* within the time allocated to the process. This is often performed without adequate quality control (quality that in principle should be guaranteed by the solely propensity toward the internationalization and by the international recognition of research).

Actually, as speculated in the past, the smartness/attractiveness of an ecosystem does not depend exclusively on its ability to make operate “all gears of a machine” in an effective and efficient manner. It rather, depends on its ability to create an environment able to meet the individuals’ basic needs and keep them in a state of positive tension in which their skills are stimulated by adequate challenges till the learner achieve self-realization [6]. Only under such conditions, individuals will ”live” the territory and feel encouraged to innovate it, thus contributing to the economic development and to the social well-being. Accordingly we need a different approach to monitor and evaluate learning ecosystems. A bottom-up approach, that fully involves students and, possibly, all other categories contributing greatly to the success of the educational process. This approach should be based on a different framework of reference and, at the same time, should be considered complementary to the top-down evaluation approaches representing the other side of the coin.

2 The Bottom-Up Evaluation Model and the Test-beds

The building up of the framework of reference, from which the bottom-up approach to the measure the ”smartness" of a learning ecosystems has been derived, has been inspired by the Maslow’s Pyramid [7] and the definition of Flow state [8]. Accordingly, provided that basic individual’s needs making up the pyramid are satisfied, all individual actors of the learning process - in particular students - are candidate to achieve a state of flow [6]: i.e. a state where challenges are exciting and adequate to the owned skills that, in turn, are expected to improve because of the challenges.
While referring the reader for a detailed description to [9], here we briefly resume the adopted procedure. First we have mapped internal and external elements of the learning eco-system - infrastructures, services, social life, challenges, skills, etc. - and data typologies (subjective and objective, qualitative and quantitative) onto the Maslow's Pyramid, redefining its inner layers. On such basis we have afterwards elaborated a questionnaire aimed at collecting the opinions of actors and stakeholders within the learning eco-systems, in our case university campuses. The questionnaire has been designed to collect both numerical indicators and textual opinions and is reported in Appendix A.

Some members of the Smart City Learning Observatory [12], then, decided to start the trial phase with a sample of university students. The total number of students involved was 807 distributed among the six universities that participated in the trial for the academic year 2014-2015 as follow: 81 from the University of Rome Tor Vergata, 51 from the Polytechnic of Turin and University Politehnica of Bucharest, 47 from the University of Craiova, 257 from the Politehnica University of Timisoara University and 320 from the Aalborg University. The difference in the number of participants among the universities is deemed not to have any influence on the comparative study since for a number of participants equal to or greater than 40 the numerical outcomes of the survey tend to stabilize within a variability range that does not exceed few tenths of percent.

3 Data analysis

Table 1 shows the average values of the 10 numerical indicators produced by the questionnaire (see Appendix A). Such indicators represent the outcomes of the mapping procedure described above and were expected, anyway, to be affected by possible correlations, to be investigated once that the first sets of data were collected from a reasonable number of universities.

Table 1. Average values of the indicators produced by the questionnaire in Appendix A.

Indicator/University	Rome	Bucharest	Craiova	Aalborg	Turin	Timisoara
Infrastructure	5,86	6,37	5,98	7,12	5,64	7,26
Food services	5,94	7,47	4,91	7,07	6,22	6,15
Environment	6,35	7,30	5,20	6,50	6,53	6,49
Info/admin services	5,91	6,75	7,08	6,93	5,82	7,07
Mobility	6,40	7,61	7,67	7,39	6,82	7,93
Safety	6,24	7,35	7,62	8,92	7,47	7,88
Support to social interactions	5,28	7,14	7,30	6,83	6,04	7,14
Satisfaction	6,85	6,65	7,18	7,35	6,7	7,18
Challenge	5,38	7,06	7,36	7,49	6,06	7,04
Self-fulfillment	6,98	6,72	7,01	7,55	7,02	7,13

Fig. 1a shows a snapshot of the cross-correlations among indicators. Some of them - *Mobility*, *Easy access to info and admin services* and *Safety* - show important correlation (>= 0,35) with quite a high number of the measured indicators (*seven*) and, thus, can be removed to produce a reduced space of representation, shown by Fig. 1b, characterized by reasonably light correlations. However, It is worthwhile to highlight that it is almost impossible to obtain a space of fully independent indicators. This is the reason why we have applied on the residual dimensions (see Fig. 1b) a Principal Component Analysis (PCA) [10,11], to obtain a orthogonal space of representation composed by the the principal components (PC), see Figs. 2a and 2b).

Fig. 1. (a) Snapshot on the correlations among the full set of indicators; (b) Residual correlations among the subset of 7 indicators upon drop out of *Mobility*, *Info/Admin services* and *Safety*

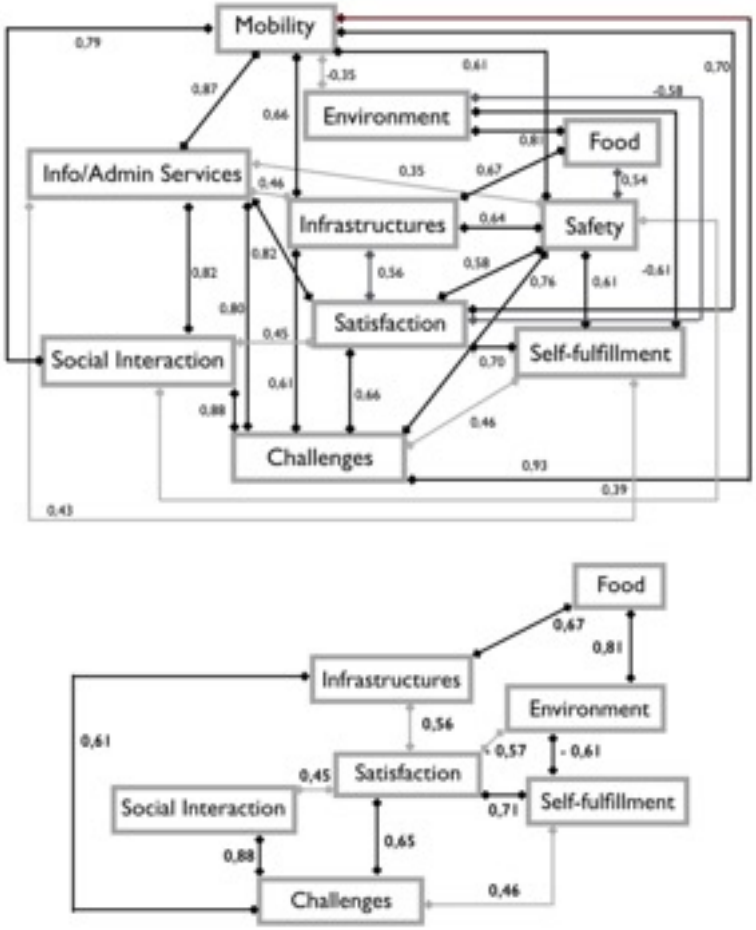
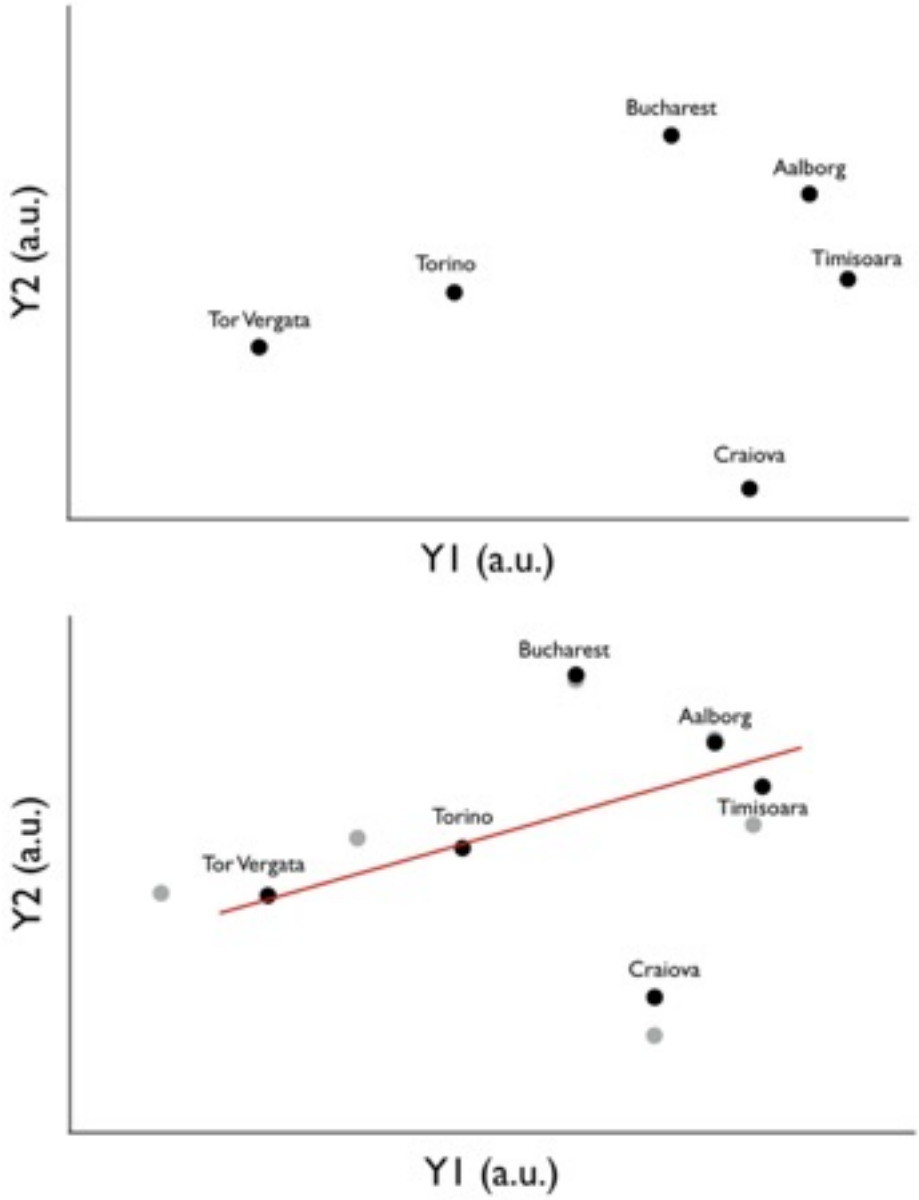


Fig. 2. Positioning of the universities on the plane identified by the two principal components, Y1 and Y2, derived from the PCA for the case in which we considered: (a) the full set of 10 indicators; (b) the reduced set of 7 indicators shown in Fig. 1b where grey circle represent the relative position of the universities in Fig. 2a (same metrics for both axis)



We have opted not to remove the indicator *Satisfaction*, because by inspection we have verified that its removal would have affected consistently the relative positioning of the universities into the plane of the two principal components. In addition we have verified by inspection that none of the other indicators can be removed, except for the *Food facilites* without significantly affecting the representation. The removal of the *Food facilites* induces slight, though visible changes, probably because of its strong correlation with the *Environment* indicator.
Figs. 2a and 2b show the comparison between the case where we considered all 10 indicators, or only the subspace of 7 less-correlated indicators reported by Fig. 1b. Overall, the two representations are similar in terms of placing the corresponding university onto the 2 orthogonal PCA dimensions.
According to the students, thus, the space of indicators useful to evaluate a learning ecosystem can be reasonably limited to the two *basic physical* indicators *Infrastructure* and *Food facilities,* to which one has to add all the dimensions related to the highest human needs (see Maslow's Pyramid): *Support to social interaction*, *Satisfaction* of the study course of study, *Self-fulfillment* (composed of skills acquisition and of personal potentialities development) and possibility to *be challenged*. These results confirm our initial working hypothesis and emphasize the adequacy of the proposed approach.

Now, the main research question arises: *How can these indicators be combined to determine the "smartness" of a learning ecosystem ?*
To answer this question it is necessary to analyze the contribution of each of the seven parameters to the two principal components, Y1 and Y2, of Fig. 2.
The indicator *Infrastructure* contributes in an equitable manner to both principal components. While *Food services* and *Environment* determine the positioning of the universities along Y2 the remaining four indicators determine their positioning along Y1. Therefore the universities characterized by a high value in all indicators position themselves at the top right of the plane of representation. Accordingly we can draw the straight line of Fig. 3, which represents the *axis of smartness* that increases with Y1 and Y2. Deviations in the positioning of the universities along this axis, (see Fig. 3) are mainly determined by a substantial deviation of one of the indicators that contribute to the vertical positioning with respect to the average values of all other indicators: for example, in the perception of the students, University of Craiova underperforms in *Food services*, while University Politehnica of Bucharest over-performs in the same indicator, always compared to the average values taken by all other parameters.
It is worthwhile to stress that the pictures derived from our analysis may not fully coincide with the outcomes derived from top-down approaches to university

benchmarking. As example in our bottom-up approach, obviously, the "quality" of the scientific and technological research is not directly evaluated. However if the research or the transfer of its outcomes to the productive systems are not able to generate challenges for students they will not contribute to increase the value of the *Challenge* indicator. When discrepancies among top-down and bottom-up approaches are detected it may be necessary to put in place adequate countermeasures because research risks be perceived as a "reserve", difficult to access, and failing to stimulate the propensity towards the innovation of the majority of students, thus generating a loss of potentiality of the whole system. The same applies when the productive system under-utilizes the skills acquired by graduated students during their studies. This would result in the reduction of potentialities that could be expressed by the human resources who, in turn, will possibly never achieve a state a flow.
Generalizing, we can state that there is a potential problem in the learning ecosystem that must be identified and mitigated any time the outcomes of the indicators for processes and/or products do not coincide with the customers' perception (in our case the students).

4 Future Developments

Apart from the obvious goals to extend the number of universities involved in the trials and to disseminate the culture of the bottom-up evaluation approach, one of our additional future objectives consists in extending our method to explore the mediation role of technologies in supporting the acquisition of an increasing level of smartness.
Since the questionnaire has been designed to be easily adaptable to measure the smartness of any learning ecosystem, whether physical or virtual, a future research objective is its adaptation to measure the smartness of schools. Preliminary experiments in this direction have already started.

This current work describes only a comparative analysis of the data collected by the six universities. A detailed analysis of the results obtained for each university is underway.

Acknowledgements. This work has been partially funded by the Sectorial Operational Program Human Resources Development 2007-2013 of the Romanian Ministry of European Funds according to the Financial Agreement POSDRU/159/1.5/S/134398.

5 References

1. Italian University Ranking 2015 by Il sole 24 Ore: http://www.ilsole24ore.com/speciali/classifiche_universita_2014/home.shtml (Retrieved on July 2015)
2. Italian University Ranking 2015 by Censis: http://www.censismaster.it/document/it/

Classifica_completa_Censis_delle_Universita_italiane_2014_2015/Classifiche (Retrieved on July 2015)
3. Giovannella C., Where's the smartness of learning in smart territories?, IxD&A Journal, 22, 59–67, (2014)
4. Top Universities: http://www.topuniversities.com/ (Retrieved on July 2015)
5. U-Multirank: http://www.umultirank.org/ (Retrieved on July 2015)
6. Giovannella C., Smart Territory Analytics: toward a shared vision. In: SIS 2014, CUEC, (2014).
7. Maslow A. H., A theory of human motivation, Psychological Review 50 (4), 370–396 (1943)
8. Czisikszentmihalyi M., Flow - The Psychology of Optimal Experience. Harper & Row (1990)
9. Giovannella C., Territorial Smartness and Emergent Behaviors. In ICSCS 2013, IEEE publisher, 170–176 (2013).
10. 1. Jolliffe, I.T.: Principal Component Analysis, Springer Series in Statistics, 2nd ed., Springer, NY (2002)
11. PCA https://en.wikipedia.org/wiki/Principal_component_analysis
12. SCLO http://www.mifav.uniroma2.it/inevent/events/sclo/index.php?s=167

Appendix A

Questionnaire (questions on personal information - e.g. sex, age, etc. - have not been included)

1) *Basic needs:* on a scale 1-10, if you live in student or rented house, please indicate how satisfied you are about your living arrangement.
2) *Basic needs:* with respect to the previous question, please comment also on the problems you may have encountered (open answer)
3) *Basic needs:* How do you usually move ?
Car
Moto
Public transportation
University shuttles
Bicycle
On foot
Other solution (please specify)
4) *Basic needs:* with respect to the previous question, could you please explain the reason of your choice ?
5) *Basic needs:* on a scale 1-10, please indicate how easy is to move within your campus/ university area and within the University buildings.
6) *Basic needs:* with respect to the previous question, please comment on any mobility or orientation problems you may have experienced (open answer)
7) Basic needs: when you have to stay a full day long at your University where do you take your lunch ?
At home
At the University/Campus canteen
In a bar/pub/restaurant
I bring my lunch-box
Other solution (please specify)
8) *Basic needs*: with respect to the previous question, could you please explain the reason of your choice? (open answer)
9) *Basic needs:* On a scale 1-10, please indicate the level of appropriateness of the basic facilities, like bar, canteens, restaurants and access to drinking water are appropriate.

10) *Basic needs:* with respect to the previous question, please comment also on the problems you may have encountered (open answer).
11) *Environment:* on a scale 1-10, please indicate your perception on the "green level" of the Campus (availability and care of green areas, air quality, separate waste collection, etc..)
12) *Environment:* with respect to the previous question, is there any specific problem you wish to point out? (open answer)
13) *Safety:* on a scale 1-10, please indicate how safe you feel on campus (not only on a physical level).
14) *Safety:* with respect to the previous question, is there any problem you wish to point out? (open answer)
15) *Infrastructures:* on a scale 1-10, please indicate how University infrastructures (classrooms, libraries, laboratories, areas students, WI-FI) are adequate for the activities you are carrying out on campus?
16) *Infrastructures:* with respect to the previous question, are there any problems to point out or infrastructure improvements to suggest? (open answer)
17) *Infrastructures:* which infrastructures or services may improve your experience in the campus/university and make it more adequate to your needs ?
18) *Internet:* Which device do you use to connect to the Internet from within the Campus/ University ?
Smart Phone
Tablet
Laptop
Desk computer
Other solution (please specify)
19) *Internet:* How do you connect to the Internet ?
Campus/University WI-FI
Private provider
Other solution (please specify)
20) *Internet:* How long are you connected to the Internet on Campus/at the University ?
I do not connect
Less than half an hour
More than half an hour less than two hours
More than two hours less than five hours
I am always on
21) *Internet:* as far as Internet connection do you have any problems to point out or suggestions? (open answer)
22) *Administrative and information services:* on a scale 1-10, please indicate how, in your opinion, does your University provide easy access to information (considering also the support given by the website).
23) *Administrative and information services:* on a scale 1-10, please indicate how, in your opinion, does your University facilitate the accomplishment of administrative procedures (considering also the support given by the website).
24) *Administrative and information services:* with respect to the previous question, do you have any problems to point out or service improvements to suggest? (open answer)
25) *Social interaction:* on a scale 1-10, please indicate how in your opinion, does your University support social interaction (student/worker organizations, web environment, cultural and sports activities, interaction with the surrounding territory, etc.)
26) Social interaction: with respect to the previous question, do you have any problems to point out or improvements to suggest? (open answer)
27) *Challenges and opportunities:* on a scale 1-10, please indicate how much do you feel that the University is able to challenge you and/or offer appealing opportunities (exchanges and scholarships, participation in projects with concrete impact, internships, etc..).
28) *Challenges and opportunities:* with respect to the previous question, do you have any suggestions on possible initiatives? (open answer)

29) *Satisfaction:* on a scale 1-10, please indicate how satisfied you are with the quality of the curricula you have undertaken (if student) or the work you are carrying out (if member of the faculty).
30) *Satisfaction:* how can your satisfaction be improved? (open answer)
31) *Self-actualization:* on a scale 1-10, please indicate how, in your opinion, skills and competences you are currently developing may meet those requested by the working domain in which you operate or wish to operate in the future
32) *Self-actualization:* on a scale 1-10, please indicate to which extend your University has been/is able to develop your potentialities.
33) *Self-actualization:* how can your self-actualization could be improved? (open answer)